Class-11th + 12th

Kattar Advanced

EaJEE NOTES

for

INORGANIC CHEMISTRY

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(IIT Delhi)

Pyare ARJUNA
Tere PRAYAS se hi
LAKSHYA Bheda Jayega

JEE Main & Advanced
Theory and PYQ's

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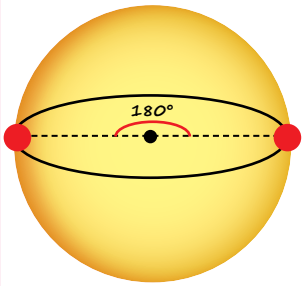
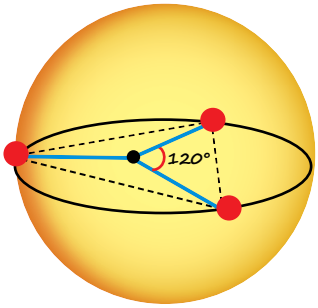
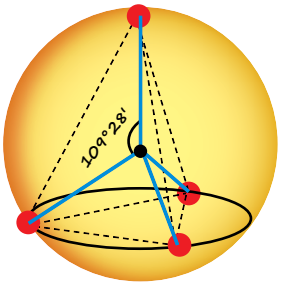
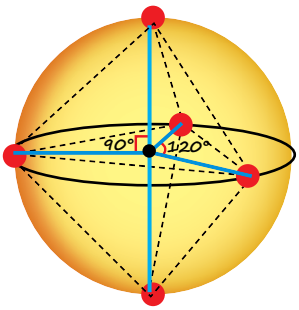
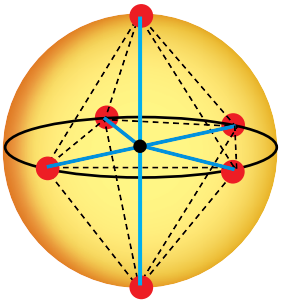
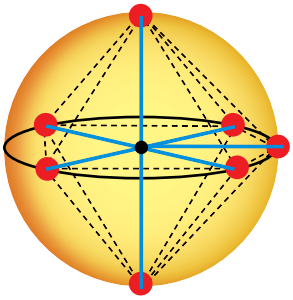
Notes

EaJEE Notes for Inorganic Chemistry is available on Amazon and PW Store.

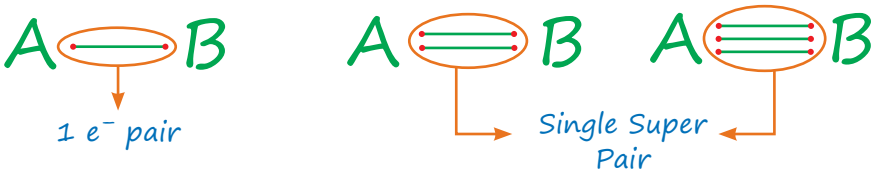
VSEPR THEORY
VALENCE SHELL ELECTRON PAIR REPULSION THEORY

Main Postulates

- The shape of a molecule depends upon the number of valence shell electron pairs [bonded or non-bonded] around the central atom. se
- The valence shell is taken as a sphere with the electron pairs localising on the spherical surface at maximum distance from one another.
- Pairs of electrons in the valence shell repel one another since their electron clouds are negatively charged.
- These pairs of electrons tend to occupy such positions in space that minimise repulsion and thus maximise distance between them.

2 electron pairs are localised on spherical surface at maximum distance, when angle between them is 180°.		3 electron pairs are localised on spherical surface at maximum distance, when they are placed at corners at triangle.	
4 electron pairs are localised on spherical surface at maximum distance, when they are placed at corners of tetrahedron.		5 electron pairs are localised on spherical surface of central atom at maximum distance when 3 are placed at equatorial position [at angle 120°] and 2 are placed at axial positon [at angle 90°]	
6 electron pairs are localised on spherical surface at maximum distance, when they are placed at corners of octahedron.		7 electron pairs at maximum distance is shown in figure	

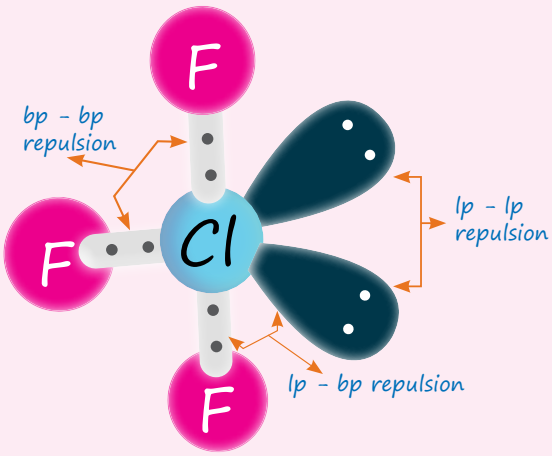
- A multiple bond is treated as if it is a single electron pair and the two or three electron pairs of a multiple bond are treated as a single super pair.



- Where two or more resonance structures can represent a molecule, the VSEPR model is applicable to any such structure.

The repulsive interaction of electron pairs decrease in the order:

Lone pair (lp) - Lone pair (lp) > Lone pair (lp) - Bond pair (bp) > Bond pair (bp) - Bond pair (bp)



- The lone pair are localized on the central atom, each bonded pair is shared between two atoms. As a result, the lone pair electrons in a molecule occupy more space as compared to the bonding pairs of electrons.

- We can represent any molecule in AB_xL_y form where, A → Central atom, B → Side atom, L → Lone pair
- Number of valence shell electron pair decides the geometry of a molecule.

Valence shell electron pair [VSEP] = x + y

AB_2 Type Molecule

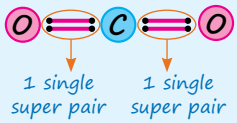
CO_2

AB_2L_0

x = 2

y = 0

- Valence shell electron pair = 2
- Geometry → Linear
- Bond angle → 180°



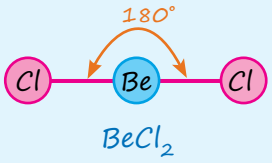
$BeCl_2$

AB_2L_0

x = 2

y = 0

- Valence shell electron pair = 2
- Geometry → Linear
- Bond angle → 180°



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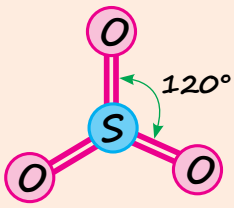
AB_3 Type Molecule

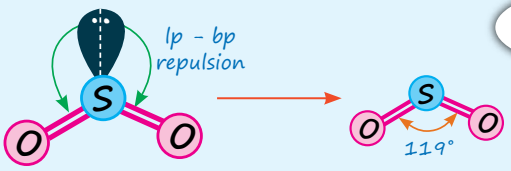
SO_3 → AB_3L_0 → $x = 3$, $y = 0$

- Valence shell electron pair = 3 + 0 = 3
- Geometry → Trigonal planar
- Bond angle → 120°



SO_2 → AB_2L_1 → $x = 2$, $y = 1$

- Valence shell electron pair = 2 + 1 = 3
- Due to lp - bp repulsion, bond angle reduces from 120° to 119°



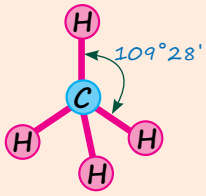
Geometry → Trigonal planar Shape → Bent

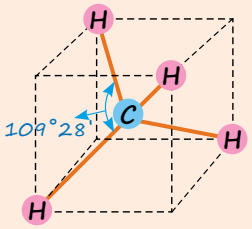
Structure with lone pair → Geometry
Structure without lone pair → Shape

AB_4 Type Molecule

CH_4 → AB_4L_0 → $x = 4$, $y = 0$

- Valence shell electron pair = 4 + 0 = 4
- Geometry → Tetrahedral
- Bond angle → 109° 28'

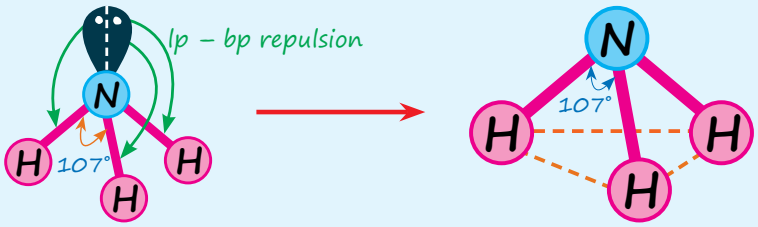




C → At body centre of cube
H → At alternate corners of cube

NH_3 → AB_3L_1 → $x = 3$, $y = 1$

- Valence shell electron pair = 3 + 1 = 4
- Due to lp – bp repulsion, bond angle reduces from ideal tetrahedral angle 109° 28' to 107°.

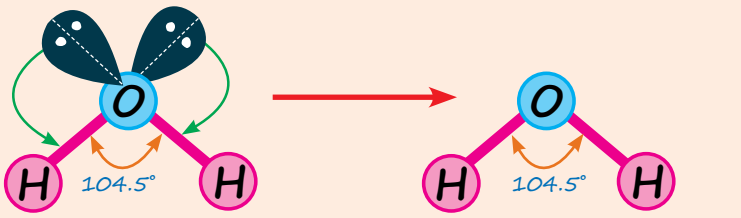


Geometry — Tetrahedral Shape — Pyramidal

H_2O → AB_2L_2

- $x = 2$
- $y = 2$

- Valence shell electron pair = 2 + 2 = 4
- Due to more lp – bp repulsion, bond angle reduces from 109° 28′ to 104.5°

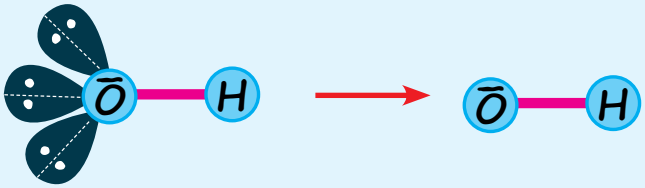


Geometry — Tetrahedral Shape — Bent, V-shaped

OH^- → ABL_3

- $x = 1$
- $y = 3$

- Valence shell electron pair = 1 + 3 = 4

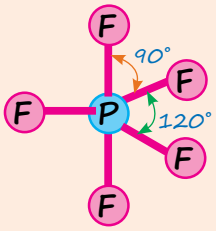


Geometry → Tetrahedral Shape → linear

AB_5 Type Molecule

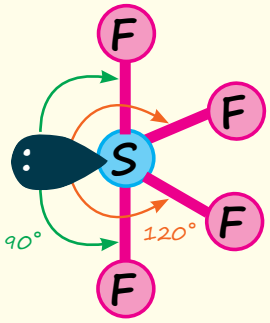
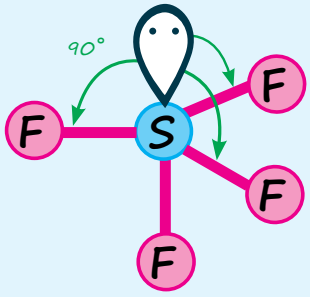
PF_5 → AB_5L_0

- Valence shell electron pair = 5 + 0 = 5
- Geometry → Trigonal bipyramidal
- θ → 90° and 120°



SF_4 → AB_4L_1

- Valence shell electron pair = 4 + 1 = 5

Case–1 If lp is present at equatorial position	Case–2 If lp is present at axial position
	
There are 2 lp – bp repulsions at 90° and 2 lp – bp repulsions at 120°.	There are 3 lp – bp repulsions at 90°.

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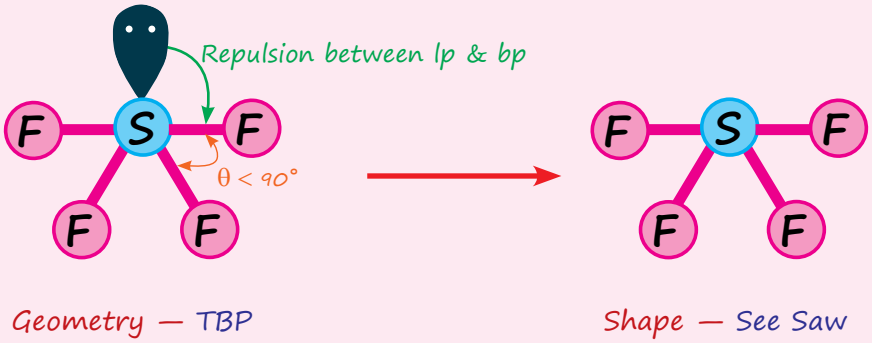
- Repulsions at 90° are more effective than 120°. So we are going to compare on the basis of repulsions at 90°.
- Case – 1 structure is more favorable than case-2 due to less repulsion.
- So, case – 1 structure is Acceptable on the basis of postulates of VSEPR theory.



Geometry — TBP Shape — See Saw

Note

In TBP geometry due to less repulsion, more favorable position for lone pair is equatorial position.

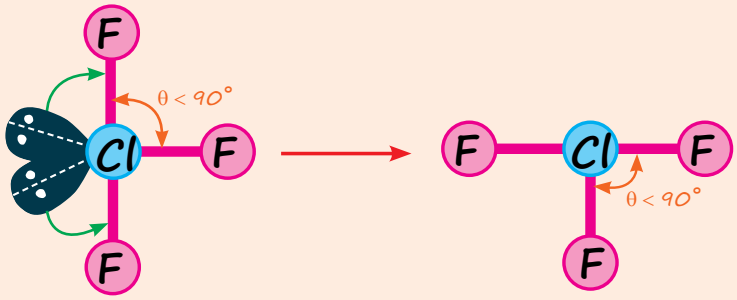
ClF_3

AB_3L_2

$x = 3$

$y = 2$

- Valence shell electron pair = 3 + 2 = 5



TBP Geometry Bent T shaped

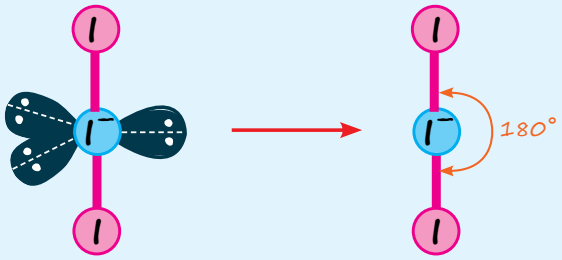
I_3^-

AB_2L_3

$x = 2$

$y = 3$

- Valence shell electron pair = 2 + 3 = 5



TBP Geometry Linear shape

AB_6 Type Molecule

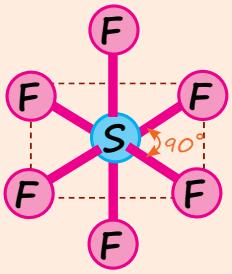
SF_6

- Valence shell electron pair = 6 + 0 = 6
- Geometry → Octahedral
- Bond angle → 90°

AB_6L_0

$x = 6$

$y = 0$



BrF_5

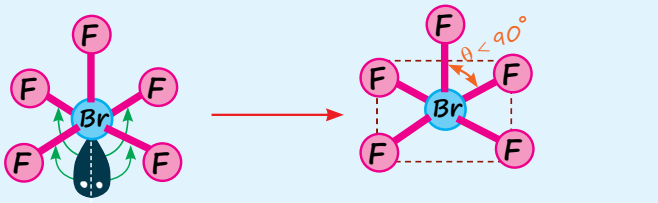
- Valence shell elctron pair = 5 + 1 = 6
- All bond angles are less than 90°

The lone pair would force the Br-F bond pairs upward, and all Br-F bond angles would contract.

AB_5L_1

$x = 5$

$y = 1$



Geometry - Octahedral Shape → Square Pyramidal

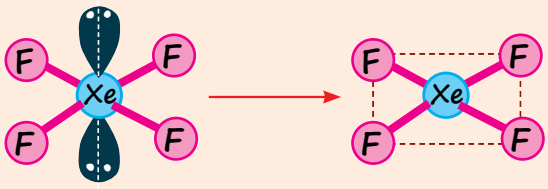
XeF_4

- Valence shell electron pair = 4 + 2 = 6
- Bond angle → 90°

AB_4L_2

$x = 4$

$y = 2$



Geometry- octahedral shape – Square planar

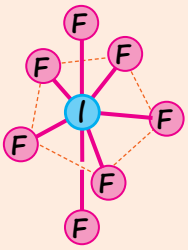
AB_7 Type Molecule

IF_7

AB_7L_0

$x = 7$

$y = 0$



IF_7 [θ = 72°, 90']

Pentagonal bipyramidal Geometry

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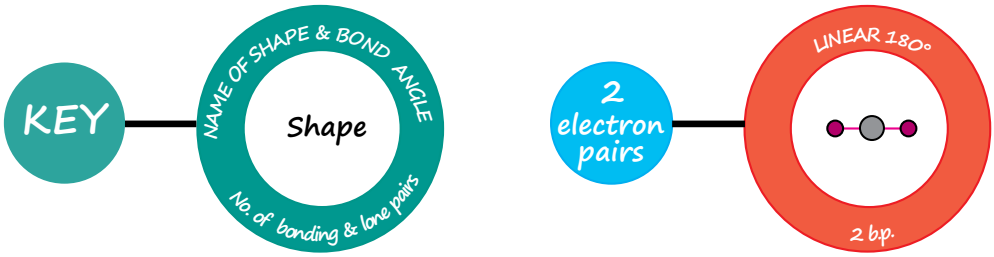
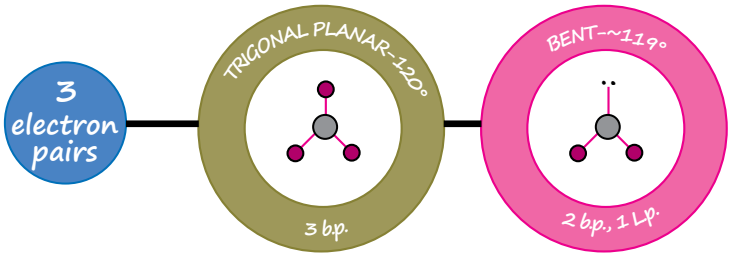
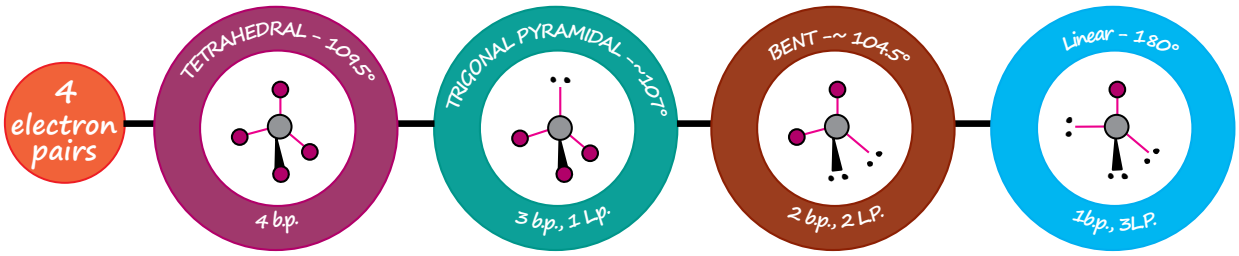
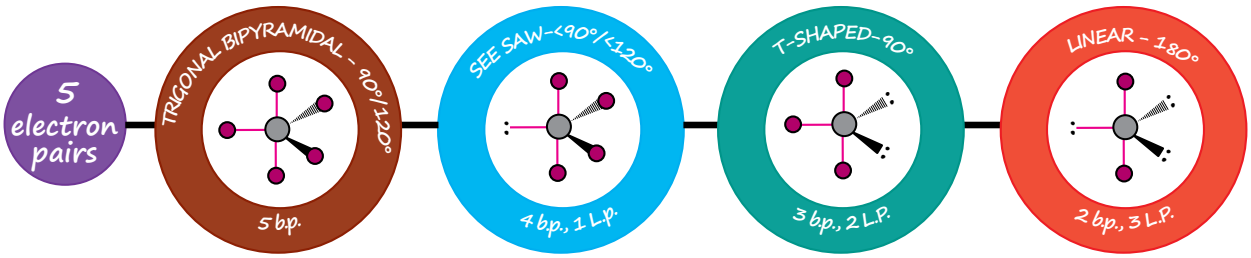
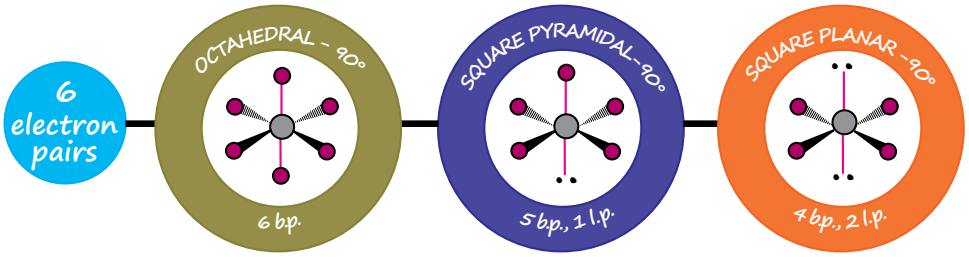
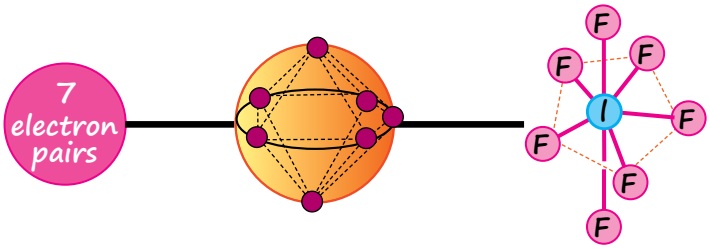












IF_7 [θ = 72°, 90']
Pentagonal bipyramidal Geometry

6. **In the structure of SF_4, the lone pair of electrons on S is** [27 June, 2022 (Shift-II)]

(a) Equatorial position and there are two lone pair – bond pair repulsions at 90°.

(b) Equatorial position and there are three lone pair – bond pair repulsions at 90°.

(c) Axial position and there are three lone pair – bond pair repulsion at 90°.

(d) Axial position and there are two lone pair – bond pair repulsion at 90°.

Sol. (a)

7. **Based upon VSEPR theory, match the shape (geometry) of the molecules in List-I with the molecules in List-II and select the most appropriate option.** [27 June, 2022 (Shift-I)]

List-I (Shape)			List-II (Molecules)
A.	T-shaped	I.	XeF_4
B.	Trigonal planar	II.	SF_4
C.	Square planar	III.	ClF_3
D.	See-saw	IV.	BF_3

(a) (A)-(I), (B)-(II), (C)-(III), (D)-(IV)

(b) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

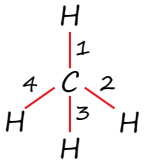
(c) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)

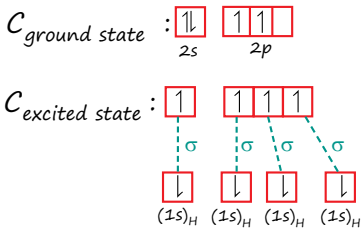
(d) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)

Sol. (b)

NEED OF NEW CONCEPT → (HYBRIDISATION)

Bonding in CH_4 according to VBT





- 2 different types of overlapping
  - $(2s)_C - (1s)_H$
  - $(2p)_C - (1s)_H$
- 2 Different bond lengths.

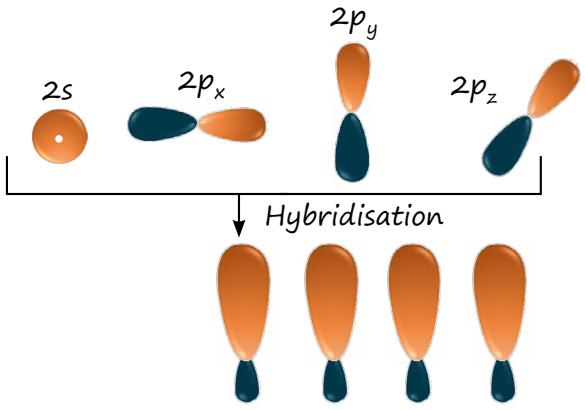
VBT predicts that the 3 bonds formed through s-p overlap would be the same and differ from the 4th bond formed through s-s overlap. This difference in bond types would result in unequal bond lengths which is not what is observed in methane.

Experimental Fact All C — H bonds are same in CH_4. → This fact can be explained by new theory ⇒ Hybridisation

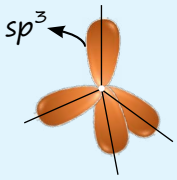
Hybridisation in CH_4

$C_{excited\ state}$: 1 (2s) 1 1 1 (2p)

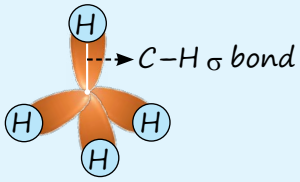
E ↑ 1 1 1 (2p) 1 (2s) → sp^3 sp^3 sp^3 sp^3 — 4 New Hybrid Orbitals

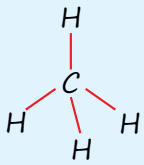


4 hybrid Orbitals (sp^3)



4 H →





4 sp^3 hybrid orbitals of carbon at 109° 28′

Overlapping between sp^3 hybrid orbital of carbon and 1s atomic orbital of hydrogen

All C—H bonds are equal in length.

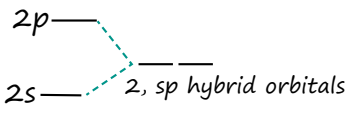
HYBRIDISATION

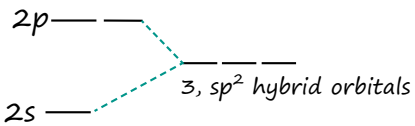
Inter Mixing of pure atomic orbitals before bonding to produce new hybrid orbitals, specially for bonding purpose.

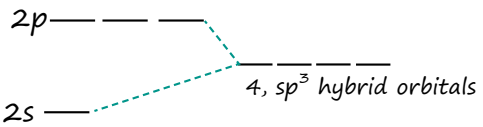
Postulates

(i) It is a hypothetical concept.

(ii) Only those orbitals can take part in hybridisation which have comparable (almost equal) energies.







(iii) The number of hybrid orbitals generated will be equal to the number of pure atomic orbitals taking part in hybridisation.

(iv) All 3 type of orbitals (having a pair of electrons ⇅ or having a unpaired electron ↑ or completely empty ☐) can take part in hybridisation.

(v) The hybrid orbital generated will be represented by

Bigger lobe will be used for bonding.

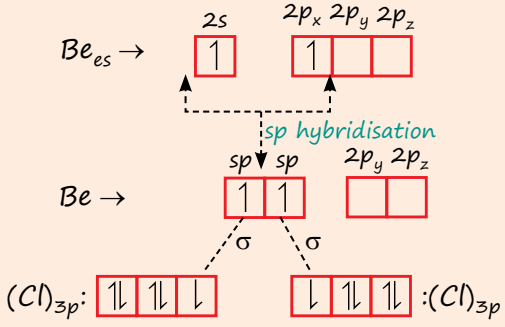
Steric Number Rule

Steric number = No. of lone pairs + No. of side atoms

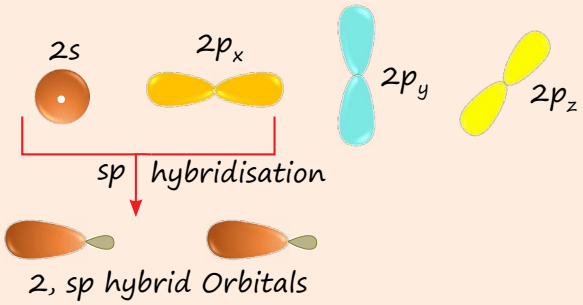
SN	Geometry	Hybridisation	Bond Angle
1	Linear	sp	$\theta = 180°$
2	Trigonal planar	sp^2	$\theta = 120°$
3	Tetrahedral	sp^3	$\theta = 109° 28'$
4	Trigonal bi-pyramidal	sp^3d	$\theta = 90°, 120°$
5	Octahedral	sp^3d^2	$\theta = 90°$
6	Pentagonal bi-pyramidal	sp^3d^3	$\theta = 90°, 72°$

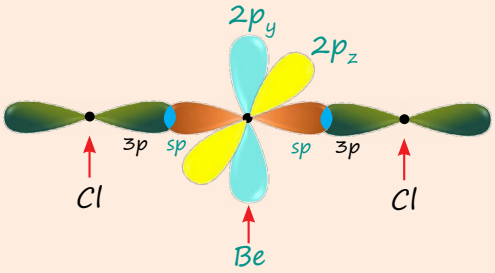
sp Hybridisation

$BeCl_2$ $\quad Cl - Be - Cl$

- SN = LP + SA = 0 + 2
  = ② → sp hybridisation
- 

- 2 Be — Cl σ bonds : $(sp)_{Be} - (3p)_{Cl}$
- 2 vacant orbitals ($2p_y$ and $2p_z$) at Be.





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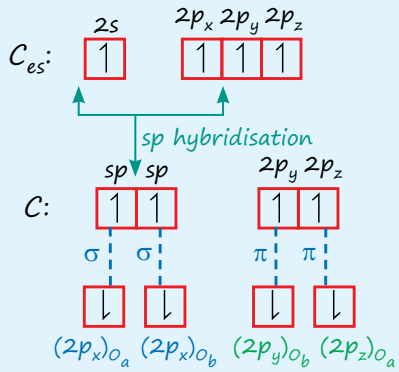
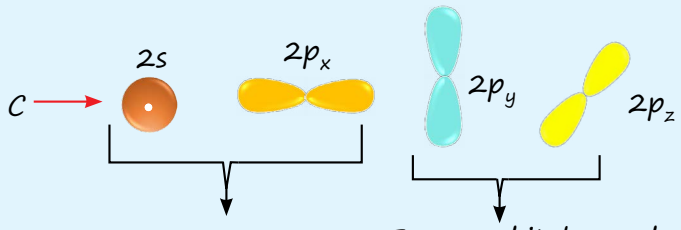
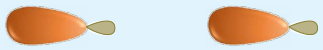
CO_2

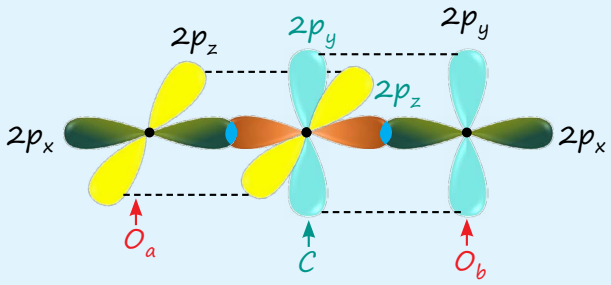
$O = C = O$

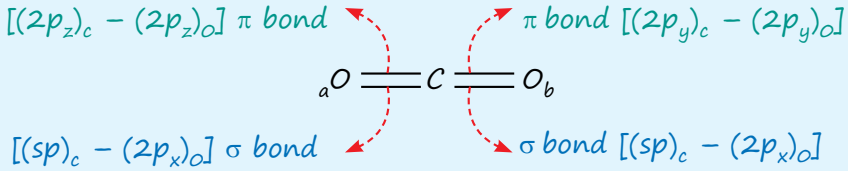
- SN = LP + SA
  = 0 + 2
  = 2 → sp hybridisation









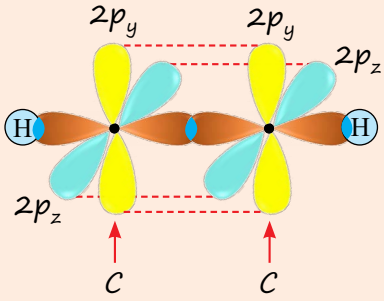


C_2H_2

$H—C \equiv C—H$

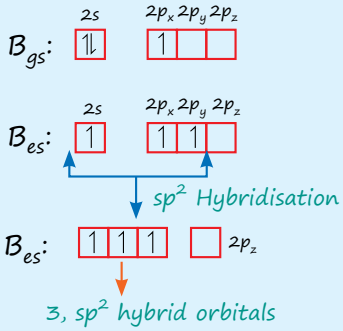
- 2 C—H σ bonds : $(sp)_C - (1s)_H$
- 1 C—C σ bond : $(sp)_C - (sp)_C$
- 2 C—C π bonds : $(2p_y)_C - (2p_y)_C$ and $(2p_z)_C - (2p_z)_C$

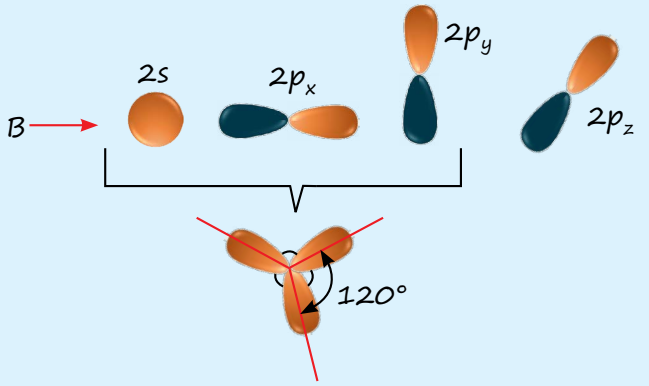
Molecular plane → H— C ≡ C — H



sp^2 Hybridisation

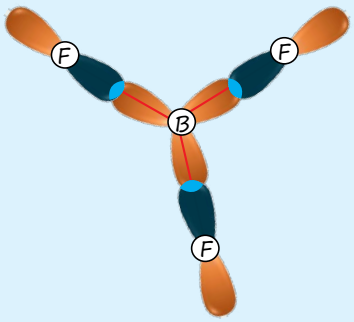
BF_3

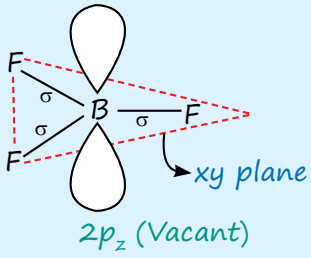




- 3 sp^2 hybrid orbitals are arranged at 120° before bonding.

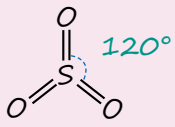
- F: 2s ⇅ | 2p_z 2p_y 2p_x ⇅ ⇅ 1
- 3 σ B — F bonds: $(sp^2)_B - (2p_x)_F$
- $sp^2 \equiv s + p_x + p_y$





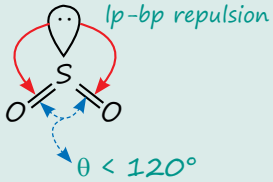
$2p_z$ (Vacant)

SO_3



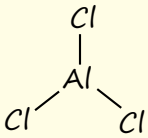
- SN = 0 + 3 = 3
- $hyb^n = sp^2$
- Shape = Trigonal planar

SO_2



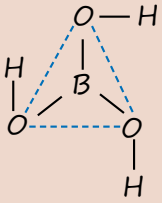
- SN = 1 + 2 = 3
- sp^2
- v shaped

$AlCl_3$



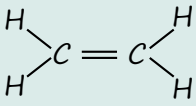
- SN = 0 + 3 = 3
- sp^2
- Trigonal planar

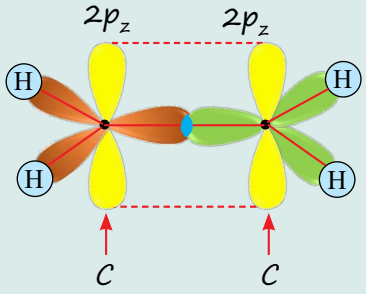
H_3BO_3



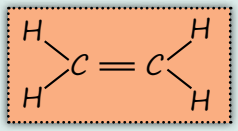
- SN = 0 + 3
- sp^2
- Trigonal planar

C_2H_4





- $sp^2 \equiv s + p_x + p_y$
- 4 C—H σ bonds : $(sp^2)_c - (1s)_H$
- 1 C—C σ bond : $(sp^2)_c - (sp^2)_c$
- 1 C—C π bond : $(2p)_c - (2p)_c$
- Molecular plane →



- Max. no of atoms in a plane = 6

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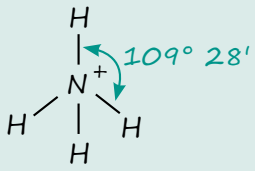
sp^3 Hybridisation → Geometry : Tetrahedral

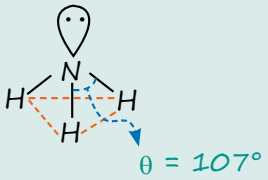
$NH_4^{\oplus}$

- SN = 0 + 4
- sp^3
- Tetrahedral



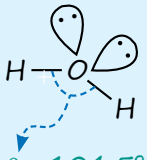
NH_3

- SN = 1 + 3 = 4
- sp^3
- Pyramidal



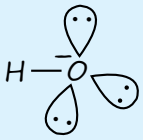
H_2O

- SN = LP + SA
  = 2 + 2 = 4
- sp^3
- V shape



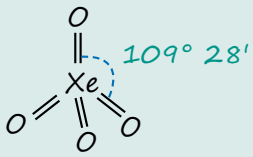
HO^-

- SN = 3 + 1 = 4
- sp^3
- Linear



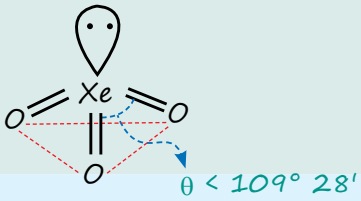
XeO_4

- SN = 0 + 4 = 4
- sp^3
- Tetrahedral



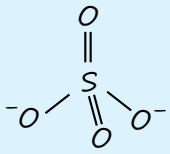
XeO_3

- SN = 1 + 3 = 4
- sp^3
- Pyramidal



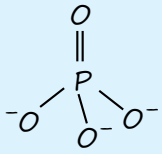
SO_4^{2-}

- SN = 0 + 4 = 4
- sp^3
- Tetrahedral



PO_4^{3-}

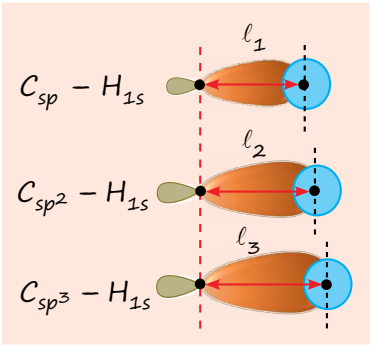
- SN = 0 + 4 = 4
- sp^3
- Tetrahedral



Orbital	% s Character	% p character
s orbital	100%	0%
p orbital	0%	100%
sp hybrid orbital	50%	50%
sp^2 hybrid orbital	33.3%	66.6%
sp^3 hybrid orbital	25%	75%

Bond Length & % s Character

- % s character: $C_{sp} > C_{sp^2} > C_{sp^3}$
- Bond length: $\ell_1 < \ell_2 < \ell_3$
- $$\text{Bond length} \propto \frac{1}{\%\ s\ \text{character}} \propto \%\ p\ \text{character}$$



Electronegativity & % s Character

- EN ∝ % s character
- % s character: $C_{sp} > C_{sp^2} > C_{sp^3}$
- Electronegativity: $C_{sp} > C_{sp^2} > C_{sp^3}$

sp^3d Hybridisation → Geometry: Trigonal bipyramidal (TBP)

PCl_5

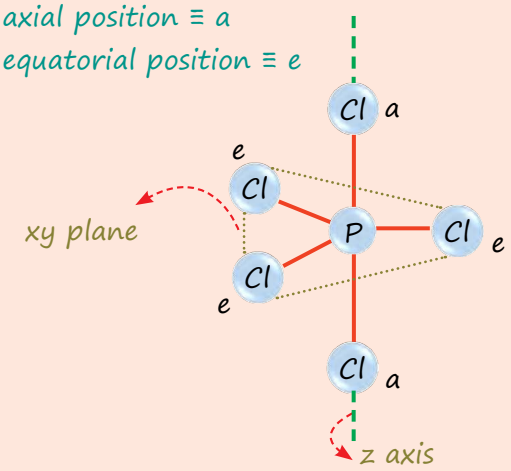
$sp^3d \equiv s + p_x + p_y + p_z + d_{z^2}$

$[sp^2]_{xy}$ — approx 100 % s character

$[pd]_z$ — approx 0 % s character

Bond length : $P - Cl_e$ < $P - Cl_a$

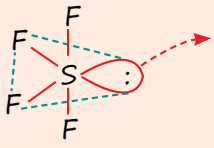
axial position ≡ a
equatorial position ≡ e



Bent's Rule

(1) Lone pair of electron prefers to occupy those hybrid orbitals which has greater % of s character.

SF_4



lone pair at equatorial position because it has more % s character than axial position.

(2) A more electronegative atom prefers to occupy that hybrid orbital which has smaller % of s character (axial position).

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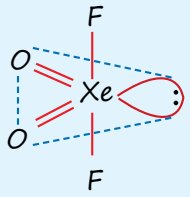
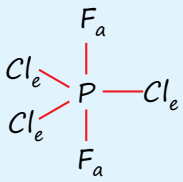
XeO_2F_2

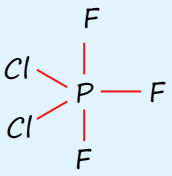
- SN = LP + SA = 1 + 4 = 5
- Geometry - TBP
- Shape - see saw



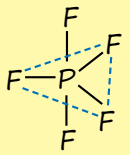
PCl_3F_2



PCl_2F_3

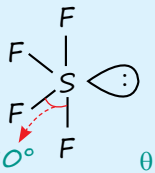


PF_5



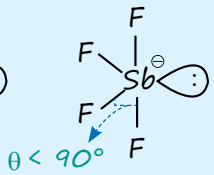
- SN = 0 + 5
- sp^3d
- TBP Shape
- BL : $P-F_a > P-F_e$

SF_4

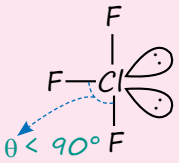


- SN = 1 + 4 = 5
- sp^3d
- See Saw Shape
- BL : $S-F_a > S-F_e$

SbF_4^-

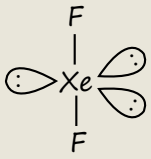


ClF_3



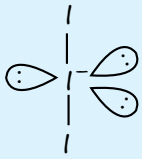
- SN = 2 + 3 = 5
- sp^3d
- Bent T shaped
- BL : $Cl-F_a > Cl-F_e$

XeF_2



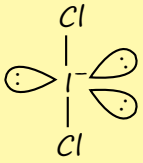
- SN = 3 + 2 = 5
- sp^3d
- Linear Shape

I_3^-



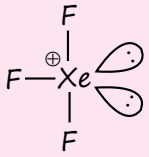
- SN = 3 + 2 =5
- sp^3d
- Linear Shape

ICl_2^-

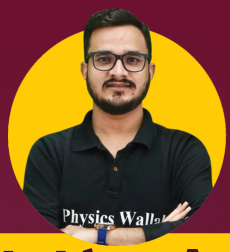


- SN = 3 + 2 =5
- sp^3d
- Linear Shape

XeF_3^+



- SN = LP + SA
  = 2 + 3 = 5
- Bent T shaped



About the Author

Mr. Om Pandey

Master of Science, IIT Delhi

With **10+ years of teaching experience**, Mr. Om Pandey is a renowned name in the field of Chemistry. A remarkable academic achiever, he secured an outstanding **AIR 100 in IIT JAM and AIR 13 & 49 in JRF**, reflecting his exceptional proficiency and deep-rooted expertise in Chemistry.

Currently teaching at Physics Wallah, Mr. Pandey has transformed the way students learn and understand Chemistry. He is especially known for his expertise in teaching **Kattar JEE Advanced**, where his focused approach and deep conceptual clarity have helped countless students crack one of the toughest exams in the country.

In addition to his teaching accomplishments, Mr. Pandey is the author of **'The Catalyst for Chemistry'**, a book designed for Class XII Board students. This book has helped a large number of students excel in their exams by simplifying complex concepts and offering effective strategies for mastering the subject.

His passion for teaching and commitment to excellence have guided thousands of students, shaping the careers of top engineers from IITs, NITs, and IIITs, as well as future doctors. His unique teaching style, coupled with his ability to simplify complex concepts, has earned him immense respect among students and peers alike.

One of his key philosophies in teaching is reflected in his popular saying, **"PYARE ♥ Chemistry samjhi ja sakti hai, bas TEACHER ke explanation me dum hona chahiye."** This belief drives his dedication to ensuring every student finds Chemistry both understandable and enjoyable.

This book, crafted with creativity and precision, is not just another resource-**it's the most effective and creative BOOK ever written for the JEE Main & Advanced exam.**

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